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Marie Curie – An Immortal Life in Science

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Family Background

Marie Curie, one of the greatest scientists of all time was born on November 7, 1867. Her father's name was Wladyslaw Skłodowski and mother, Bronislawa. She was the fifth and last child of the family. Poland was then under the rule of the Russian Tzars. There were two uprisings, one in November 1830 and the second one in January 1863, which led to the exile and imprisonment of Poles on a vast scale. Mother Bronislawa was the headmistress of a private school, one of the best schools for girls in Warsaw. She was married during summer 1860 and used to live in an apartment adjacent to her school. The couple lived there for seven years. Mdm. Bronislawa bore five children : Zofia in 1862, Jozef in 1863, Bronislawa in 1865, Helena in 1866 and finally Maria in 1867.

During January 1863 uprising, Wladyslaw's brother Zdzislaw, twice wounded in the fighting, fled to France. Bronislawa's brother Henryk, who also fought in the rebellion, was exiled in Siberia for four years. Władyslaw's father also fought in the November 1830 uprising, and was driven on foot, 140 miles north of Warsaw. However, later, he resumed his career as a teacher. He, as head of the school, insisted that talented peasants should be allowed to study with the children of the nobility. This was simply unbelievable at that time!
Thus Maria's family, both from mother and father's end, had a long political tradition.

What was the fate of the Poles in Russian Poland?

'...if he studies law, he can never become a judge, generally not even an official, without separating himself from all intercourse with his countrymen. If he studies medicine, he can never obtain a post at a university, never be at the head of a hospital, never conduct a public clinic. The result is ... he has no real mastery of anything.'

George Brandes
Danish Observer

However. science fascinated Maria's father. Maria noted, 'My father enjoyed giving explanation about Nature. Unhappily, he had no laboratory and could not perform experiments.'

What was his educational qualification? He never studied abroad or obtained any university degree. After the uprising of November 1830, the Russians closed down Warsaw University. However, Wladyslaw studied biology in Warsaw, graduating from 'biology department' without having any official status. He used to teach biology to his own children.

The family moved from the apartment adjacent to the school in 1868. A great tragedy came into the family. Mother Bronislawa died in 1878 from tuberculosis. She was out of home for treatment when Maria was five years old only. After leaving her teaching job, Bronislawa taught herself shoe making. She then opened a little shop in her apartment without any resentment for doing the so-called 'low' occupation of a cobbler.

The family used to spend vacation with their relatives in countrysides. Maria wrote later, 'I owe my love for the country and nature.' She lost her mother at ten years of her age. She had also found the tragic demise of her eldest sister Zofia two years and three months before her mother's death.

Her Education in Poland

Maria got admission at the school where her mother was a teacher. She and Helena opted for a new school in their third grade class. Helena was ten and Maria was nine then. Maria was youngest in her class. She influenced her classmates with her unusual intelligence and exceptional memory. All of her friends respected her and often asked for help in mathematics and other difficult subjects.

Maria Sklodowska graduated from Gymnasium Number Three in 1883. Jozef, their only brother, went to Medical school at Warsaw University. Admission of women in Warsaw University was forbidden at that time. What can Maria do now? She can study abroad, Paris or St. Petersburg, or she can be a teacher like her mother. What happened really?

She took almost a year's rest in the country. She boarded a train and left Warsaw for an extended visit with her maternal uncles. It was a total leisure for her. She wrote '...I have no schedule. I get up sometimes at ten o'clock, sometimes at four or five (morning, not evening!). I read no serious books, only harmless and absurd little novels...'
Maria, in her younger days, was largely influenced by positivism. Auguste Comte, the originator of the idea conceived positivism as a sort of religion whereas

Polish positivism embraced empiricism and rejected the metaphysical part of it. Comte was a believer of 'natural inferiority' of women. The polish positivists were enthusiastic supporters of women's rights.

Some of our readers may not believe the following facts now-a-days.
There was an education academy for the young Polish women which started running from 1882. Two hundred young Polish women used to meet secretly in the private apartment of the supporters where they were taught by prominent Warsaw scientists, philosophers and historians of Polish literature and culture. Somehow, Russian Police got the information and most of the teachers in the academy were forced to leave Warsaw. Maria was involved in the secret academy from its inception. Maria and Bronia, after graduation, began to take courses. In 1886, the academy became a university known as Flying University. By 1889-90, a thousand women were enrolled in Flying University.

After taking courses for one year, she decided to take a job as a governess in the family of lawyers. The family members were simply unbearable.

Maria wrote, 'I learned to know the human race a little better by being there. I learned that the characters described in novels really do exist. One must not enter into contact with people who have been demoralized by wealth.'

This kind of daily-life can not go on for ever. Bronia and Maria made a plan. Bronia will go for study in Paris within a year. Maria will continue as governess for helping Bronia and her father. Once Bronia is established, Maria will follow her.

Maria worked for four years as a governess. During this period, Maria used to teach a group of polish peasant children. She also continued her self-education. She studied Daniel's Physics, Spencer's Sociology (in French), Paul Bers' Lessons on Anatomy and Physiology (in Russian). She kept her habit of solving algebra and trigonometry.

Maria wrote, 'I was as much interested in literature and sociology as in science... I finally turned towards mathematics and physics.'

One of Maria's cousin, fourteen years older than her, had returned to Poland after studying in Russia with Mendeleev. He became the director of a positivist-influenced institution named 'Museum of Industry and Agriculture' (1875). There was a chemistry laboratory in the museum. She was allowed to work over there. She wrote in her autobiographical notes :
'I tried out various experiments described in treatises on physics and chemistry. The results were sometimes unexpected. There were also accidents and failures resulting from my inexperience.'

French biologist Claude Bernard (1813-1878) was her hero. Bernard is considered to be the 'father of modern experimental physiology'. Probably because of her free access in the chemistry laboratory, she opted for chemistry and physics over biology when she arrived in Paris.

Her Life in France

Bronia got her medical degree in 1891 and started practicing in Paris with her physician husband. Maria came to Paris during November 1891. That time, women still could not bear witness in a civil suit and could not spend their own earnings without their husband's permission. Maria took admission in Sorbonne and got *licence ès sciences* in 1893 (one out of two female licence recipients in the whole university) and *licence ès mathèmatiques* in 1894 (one out of five recipients in the whole university). A total of sixteen professors taught her. Eight were so famous that their names are found in the current Dictionary of Scientific Biography. Maria stood first in the *licence ès sciences* and second in the *licence ès mathèmatiques.*

After sometime, in the spring of 1894, she met Pierre Curie (1859-1906) who was then conducting experiments on magnetism. By that time, he had already invented a number of delicate measuring instruments. Lord Kelvin appreciated Pierre for his original contribution to the understanding of heat and work. He was a teacher in the *E'cole municipale de physique et chimie industrielle* and was least interested to submit a thesis for Ph D degree. However, Pierre presented his thesis at the Sorbonne in March 1895 and obtained Ph D shortly. Maria and Pierre married on July 26, 1895.

They were not slaves of fashion but loved bicycling. When they were in Paris, they used their bicycles whenever possible. Pierre and Maria's yearly combined income was six thousand francs, roughly three times of a school teacher and four times that of a laborer. Their income did not permit them to have servants.

Right from the very beginning, they used to do research together. Irene was born on September 12, 1897. After two months, Maria took a nurse. She wrote her father on November 10, 1897 : 'I don't want to interfere with my child's development for anything on earth.'

At the same time, her devotion for research was beyond any question. She wrote a paper 'On Magnetism of Tempered Steels' for the 'Bulletin of the Society for the Encouragement of National Industry.' It was her first published article. She concentrated on her work for submission of her PhD thesis. Eminent French physicist Henri Becquerel discovered 'radioactivity' in March 1896. She decided to work on the same though the subject was little known at that time. Pierre Curie also joined in this endevour.

They were the first to invent a highly sensitive radioactivity measuring instrument. In fact, they made an 'ionization chamber' from the left over wooden grocery crates. Inside, they introduced two circular metal plates, eight centimeters in diameter, one above the other, separated by three centimeters. On the lower plate, they placed a thin layer of the substance in question. Then they charged the lower plate with a high-voltage battery. If the substance on the plate was a conductor through air, the upper plate would gradually be charged. She first experimented with white Uranium powder obtained from Henri Moissan (NL 1906). Then she collected samples haphazardly from her colleagues around. She had detail note-books on her experiments. On February 10, 1989, she tested 13 elements including Gold and Copper. None of them produced currents as evidenced from the deflection pattern of the electrometer.

Golden Time Ahead

On February 17, 1898, she tested a heavy black pitchy mineral known as pitchblende, a mineral of Uranium. Longtime back in 1789, a self-taught chemist Martin Heinrich Klaproth extracted Uranium from this mineral. The element was used as a colouring agent in ceramics.

Marie Curie found that the mineral produces stronger current than Uranium alone. She was puzzled. Next day, she tried with several Uranium compounds as well as Uranium and pitchblende. Compounds are less active than pure Uranium. But pitchblende is more active.

On February 24, 1898, she experimented with the mineral aeschynite which contains thorium but no Uranium. It is also found to be more active than Uranium. Thorium was discovered by J. J. Berzelius in 1828.

Observation I : Thorium is more active than Uranium.

Observation II : Pitchblende is more active than either of the two.

During that period, Pierre had been turned down a professorship at Sorbonne. Jean Perrin, twelve years younger than him, got the job. Charles Friedel, who proposed Pierre's name wrote a letter to him :
'... what can one do against a normalien? ... do good work in physical chemistry in order to show these messieurs...'

The couple did not care the rejection. Pierre was then working with crystals. He left that research and joined Madam Curie (Note Book : March 18, 1898).

Why pitchblende is more active? It must contain new radioactive elements. Curies performed another experiment in between. They measured the activity of natural chalcolite. They synthesized the same by adding Uranium and Copper phosphate and compared the activity of natural chalcolite with artificial chalcolite. It was found that the latter shows less activity than Uranium. Their immediate conclusion : Natural chalcolite contains an element more active than Uranium.

In Search of New Elements

Marie Curie read a paper in the Academy titled 'Rays emitted by Uranium and Thorium compounds.' As Marie and Pierre were not the members of the Academy, the paper was read by Gabriel Lippmann, a teacher of Marie at Sorbonne. This paper was not only of finding new elements but proposed two much more important findings:

a) Novelty into physics : radioactive properties are a diagnostic for the discovery of new substances (Abraham Pais : Inward Bound).

b) As activity was found to be proportional with the amount of Uranium or Thorium, radioactivity is an atomic phenomenon.

Marie and Pierre started working with 100 gm of pitchblende. They treated the mineral with so many chemicals. They measured activity of each fraction. The fraction having highest activity was put under

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spectroscopy. No definite spectra was observed because of impurities. They invited Gustave Bemont, a chemist, to help in separation. The sample was divided into two parts. Marie got something which is 300 times active than Uranium. Pierre got 330 times active material. They performed spectroscopy. Again results are disappointing. Finally they got a part which is 400 times more active. They named it as 'Polonium' (July 13, 1898). The paper entitled 'On a New Radio-active Substance contained in Pitchblende'.

After that, there was no work for three months due to the shortage of minerals. The work again started in November 1898. They got a part which is 900 times active than Uranium. This time spectroscopy worked. A characteristic spectral line was found which was not known before.

In the note book, on 20th December 1898, Pierre marked prominently a name, 'Radium'. A paper titled 'On a New Strongly Radio-active Substance contained in Pitchblende' was read on December 26, 1898.

From the beginning of the new year, they divided their searching area. Madame decided to isolate 'Radium'. (act of a chemist). Pierre decided to find out the cause of radioactivity (act of a physicist). We cite a revealing statement from Irene :
'... it was my mother who had no fear of throwing herself, without personnel, without money, without supplies, with a warehouse for a laboratory, into daunting task of treating kilos pitchblende in order to concentrate and isolate radium.' Marie had to work with 20 kgs of material at a time.

Marie wrote, '...we were very happy ... we passed our days at the laboratory, often eating a simple student's lunch there. When we were cold, a cup of hot tea ... cheered us. We lived in a preoccupation as complete as that of a dream.' Their financial position was miserable. Marie wrote to her brother Jozef (March 1899) :
'...my husband's salary is not quite enough for us to live on. ... we have had some unexpected extra resources (i.e.. prizes) every year, which keeps us from having a deficit.'

After four long years of continuous work, in July 1902, Marie Curie announced that she had isolated one decigram of radium. We all know, radium is spontaneously luminous but it was not known to the Curies that it had a deadly potential. Their notebooks are undoubtedly very precious documents but even today they are full of radiations.

1899 and 1900 were very fruitful years. Marie wrote two papers on isolation of radium. Pierre wrote one on the effect of magnetic field on radium emission. There were three joint papers where they reported 'induced' radioactivity and electric charge of certain radium rays.

International Congress of Physics, Paris and after

Scientists from Austria, Britain, Germany, Hungary, Italy, Japan, Russia, Scandinavia, Switzerland & United States attended the congress. India also participated. Lord Kelvin, H.A. Lorentz, van't Hoff and Arrhenius were also present.

Curies read their longest paper 'The New Radioactive Substances' in the congress. They told everything except the source of energy of the 'Becquerel rays' as it was then completely unknown. Curies themselves raised the question in their paper :
'What is the source of energy coming from the Becquerel rays? Does it come from within the radioactive bodies, or from outside them?' Gravitational and electromagnetic forces (due to Newton and Maxwell) were known that time. But we had no idea about nuclear force. Marie, few years earlier, in her first paper suggested 'all of space is traversed by rays...which can only be absorbed by certain elements of high atomic weight, like Uranium & Thorium.' It means energy is brought to the radioactive substances from outside. Is it a fact?

Rutherford in January 1899, suggested that radioactive emissions are made up of at least two different kind of rays, 'beta rays' and 'alpha rays'. Madame Curie, Pierre Currie and Henry Becquerel concluded that Rutherford's 'beta particles' are identical with Professor Thomson's negatively charged particles. By 1903, Rutherford and Soddy finally proved that radioactivity is a nuclear phenomenon. It opened up the area of nuclear physics.

It is interesting to note that at the beginning, Marie was a non-believer of radioactive disintegration. However in 1906, she published a paper which shows that Polonium loses half of its activity after 140 days.

Curies got an offer in 1900 from the University of Geneva. However, they decided to stay in France. In the same year, Marie became the first woman in the faculty of the Ecole normale superieure at Sevres. It was known as country's best preparatory school for women teachers. Pierre got an offer to teach physics,

chemistry and natural history to the medical students at Sorbonne. There was a post vacant in mineralogy in 1902. He was refused for the second time. He was also refused the membership of the French academy of science. Paul Emile Appell, a well known French mathematician wished to see the name of Pierre Curie in the list of 'the Legion of Honour'. He wrote a letter to Marie :
'... I ask you to use all your influence to make sure Monsieur Curie does not refuse...'
Pierre readily replied 'I do not desire to be put on the list for decoration.'

In June 1903, Marie defended her doctoral thesis. And yes, in the same year, she got the Nobel Prize in Physics with her husband Pierre Curie and Henri Becquerel. Few nominators submitted the work of Rutherford & Soddy. Angstrom argued strongly, 'If some work be overtaken by other scientists, by no means diminish the honour for the first discovery of the phenomenon.' Marie Curie became the first woman to receive a Nobel Prize. She remained the first until her daughter Irene won the same prize in 1935. They were great scientists. They were great teachers also. Pierre wrote a letter to the Nobel Committee :
'We can not be gone from our classes at this time of year without incurring great difficulties in the teaching which is entrusted to us.' Simply unbelievable!

The announcement made a mixed reaction. Some people and press reminded us not to forget that she is a woman. In fact, 'Mrs. Curie is a devoted fellow laborer in her husband's research and has associated her name with his discoveries.' (New York Herald.)

Pierre Currie was introduced in the academy of sciences. He wrote his friend Georges Gouy :
'I find that I am in it without wanting to be and without the academy wanting to have me'. Madam was very joyful : 'Oh! me, I am only a woman'. Pierre was tried, for a second time, to confer the 'Legion of Honour'. Pierre replied, I do not feel the need of a decoration. I need a laboratory.'

In 1904, Pierre became professor of physics in Sorbonne. Pierre and Marie were provided with a large room there.

Both of them were suffering from radiation sickness. In 1906, Pierre was killed in a street accident. The professorship was offered to Marie and she became the first woman professor at Sorbonne. She continued to work on radium and isolation of polonium. In the meantime, there second daughter Eve was born on December 6,1904.

Marie as Leader of the Lab

There were seven workers in the laboratory at the time of expiry of Pierre Curie. Within three years, the number became twenty four. She got financial commitment from the University of Paris and Pasteur Institute to build a laboratory. She proved herself as a very able administrator. She was offered the 'Legion of Honour' but she refused. In 1910, she wanted to introduce her name in the French academy of sciences, a 215 years old Institute of France. Madam Curie was already a very prominent member of International Radium Standard Committee and also had her honourary membership from Swedish, Dutch, Czech and Polish academies. The clerical conservative group and the right wing press were opposing her membership and she got defeated by a vote of 60 to 85. For the next 11 years, she never requested anyone to present her paper in the academy. Irene, after receiving her Nobel Prize, also tried twice but was refused. Marguerite Perey, a doctoral student of Marie Curie (discoverer of Francium) became first woman member of the academy in 1962. She was working hard to make the 'Radium Institute' a reality.

Madam, for the first time in the world, got a second Nobel Prize in 1911 (in Chemistry) for the discovery of Radium and Polonium. She became seriously ill in 1911, was hospitalized and operated in March 1912.

World War I and Madame Curie

With a mobile X-ray vehicle, she treated the wounded soldiers in the battle field. She also donated her Nobel Medals for the cause of the war of the French people.

Madame as Institute Builder

Radium Institute was built in 1914. In 1925, she founded the Warsaw Radium Institute. She had also acted as head of the famous Pasteur Institute and a radioactivity laboratory in the University of Paris.

Her Last Days

She visited her motherland last in 1934. After few months, she breathed her last on 4th July 1934. In a sense, she sacrificed herself for the cause of science and human welfare. Her working laboratory is now transformed as 'Curie Museum'. Albert Einstein said, 'Marie Curie is, of all celebrated beings, the only one whom fame has not corrupted.'

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This year is not only the 'International Year of Chemistry'. It has been declared as 'Year of Marie Curie' by two countries Poland and France. Element with atomic number '96' is known as 'Curium'. 'The Curie' (Ci) is the unit of radioactivity. Madame will be ever-remembered in our mind. How can one forget her immemorial words, 'I mostly think of what has to be done and not of what has been done.' She cautioned the future generation of scientists by saying, 'Science is essentially international, and it is only through lack of historical sense that national qualities have been attributed to it.'

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